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Abstract

PLUTONIUM VALUE ANALYSIS

Eugene A. Eschbach (General Electric Co. - Hanford)

Several definitions used to estimate the value of plutonium as thermal reactor fuel are discussed and careful distinction is made from pricing, a complex subject involving considerable speculation beyond the scope of this work. Most analyses determine as "value" the price of plutonium for which the reactor fuel costs for each of two alternative fuels are the same. Limited insight can be gained from such values because, in practice, many alternatives are often available. Even further simplified formulations of costs and business strategies have been used to ascertain the impact of only one variable. Results of such brief analyses are often inconsistent with results of other analyses. Many of these inconsistencies are eliminated, or at least the reasons for the inconsistencies are less obscure, if one adheres to comparing costs at defined operating points considering sale and purchase of marketable materials. This methodical approach appears tedious and irritating to the physical scientist, but preserves sound business logic.

The various methods to determine the value of plutonium as a power reactor fuel are classified as practical and as abstract, and selected results are compared. Included in the practical methods are computed plutonium values for specific reactor types and economic environments; while the abstract methods involve models designed to delineate and to classify particular effects observed from "practical" computations. At this time, even "practical" calculations require assumptions and idealizations to allow solution; consequently, interpretation of the results is particularly dependent upon knowing the limitations of the value definitions.

Results of a "practical" analysis of plutonium as a successively recycled fuel for several simulated thermal reactor systems are presented and

correlation of the resulting variations of plutonium values with the isotopic composition of plutonium is described. Because consideration of successive recycle without interchange of fuel between different reactors is possibly unreal, methods of treating this larger problem are discussed.

Generally speaking, calculation of plutonium values is somewhat premature because numerous facts are insufficiently known at this time. Many of the uncertainties are compensative if plutonium values are determined by comparison with slightly enriched uranium cycles as such cycles burn plutonium in situ. However, in other important calculations, errors in key factors are cumulative. Computed examples are shown.

Uncertainties due to the inherent nature of each plutonium isotope are illustrated, such as the degree of self-shielding of the absorption resonance of plutonium-240. Less generally known, but important, is the degree of self-shielding achieved for the plutonium-239 resonances, which heavily influence the alpha value of plutonium-239.

The limitations to simplified plutonium value analysis increase as the complexity of the nuclear system considered increases. The use of plutonium to enrich thorium and of uranium-233 to enrich uranium-238 are examples, as is exchange of plutonium fuel between fast and thermal reactors. The influence of a firm market for decay heat sources, such as curium-244 and plutonium-238 (albeit an uncertain market) upon the design of thermal reactor fuel cycles is discussed.